TP-9809 DIV

A DISPOSABLE HYDROGEN FUEL SOURCE

CROSS-REFERENCE TO RELATED APPLICATION

This is a division of application serial No. 09/309,198, filed May 10, 1999, in the names of Jonathan L. Rolfe et al.

STATEMENT OF GOVERNMENT INTEREST

This invention was made with Government support under Cooperative Agreement No. DE-FC02-97EE 50483 awarded by the Department of Energy. The Government has certain rights in this invention.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to disposable hydrogen fuel sources and is directed more particularly to a device which produces hydrogen for use in fuel cells, and the like, at a selected pressure, automatically and continuously, until exhausted.

2. Description of the Prior Art

It is known to provide a small hydrogen generator for providing hydrogen for fuel cells, the hydrogen being generated by reacting a metal hydride with water or water vapor. In U.S. Patent No. 4,155,712, issued May 22, 1979, to Walter G. Taschek,

there is disclosed a hydrogen generator for providing hydrogen on demand to a fuel cell.

Taschek provides a first compartment containing a metal hydride, such as lithium aluminum hydride ($LiAlH_4$), or calcium hydride (CaH_2). The first compartment is in communication with a fuel cell. A second compartment contains water and is separated from the first compartment by a porous membrane which permits water vapor to enter the first compartment and react with the metal hydride therein to produce hydrogen (H_2). The Taschek device further includes a third compartment for retaining a reservoir of water. The third compartment is in communication with the second compartment.

When the fuel cell requires an influx of hydrogen, the pressure in the first compartment and second compartment, which are substantially equal, decrease, more so in the first compartment than in the second. The decrease in pressure in the second compartment flows water from the third compartment into the second compartment to raise the water level in the second compartment. As more water is exposed to the porous membrane, more water vapor diffuses into the first compartment to increase the hydride reaction and, thereby, the flow of hydrogen to the fuel cell.

When the fuel cell no longer requires hydrogen, the pressures in the first and second compartments increase, forcing water out of the second compartment and shutting off diffusion of water

vapor into the first compartment, thereby closing down the production of hydrogen.

It has been found that there is a delay between hydrogen demand and hydrogen production, which results in excess production for a period of time until pressure and water level stabilize at the increased rate. It has further been found that when hydrogen demand stops, and water leaves the second compartment, hydrogen production decreases promptly to a relatively low rate, but only slowly reduces thereafter until production is essentially stopped.

There is thus a need for a hydrogen generating device of the general type disclosed in Taschek, but of simpler configuration, and exhibiting more finely tuned responses to fuel cell demands for more hydrogen, or less, or no hydrogen.

SUMMARY OF THE INVENTION

An object of the invention is, therefore, to provide a hydrogen fuel source for fuel cells and other hydrogen consuming devices, of simple design and which is more reliable in providing prompt and accurate responses to the hydrogen needs of such hydrogen consuming cells and devices.

With the above and other objects in view, as will hereinafter appear, a feature of the present invention is the provision of a hydrogen fuel source comprising a first chamber, a second chamber, a hydrogen-containing material disposed in the first chamber, and a reactant disposed in the second chamber, the reactant being

adapted to react with the hydrogen-containing material to cause release of hydrogen. A discharge conduit extends from the first chamber for release of hydrogen from the first chamber. A transfer conduit interconnects the first and second chambers for flowing the reactant from the second chamber to the first chamber. A check valve is mounted in the transfer conduit and is adapted to open upon decrease in pressure in the first chamber from a selected pressure and is adapted to close upon the pressure in the first chamber rising to the selected pressure. A pressurizer acts upon the reactant in the second chamber to maintain the reactant at the selected pressure. Thus, upon opening of the check valve, the reactant in the second chamber is urged by the pressurizer to flow through the transfer conduit into the first chamber to react with the hydrogen-containing material to release hydrogen until the selected pressure in the first chamber is restored, thereby to close the check valve and to stop the flow of reactant material into the first chamber.

The above and other features of the invention, including various novel details of construction and combinations of parts, will now be more particularly described with reference to the accompanying drawings and pointed out in the claims. It will be understood that the particular devices embodying the invention are shown by way of illustration only and not as limitations of the invention. The principles and features of this invention may be

employed in various and numerous embodiments without departing from the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference is made to the accompanying drawings in which ~~is~~ are shown ~~an~~ illustrative embodiments of the invention, from which its novel features and advantages will be apparent.

In the drawings:

FIG. 1 is a diagrammatic sectional view of one form of a hydrogen source device illustrative of an embodiment of the invention;

FIG. 2 is a perspective view of a hydrogen-containing material suitable for use in the device of FIG. 1;

FIG. 3 is a diagrammatic sectional illustration of an alternative embodiment of hydrogen source device;

FIG. 4 is a diagrammatic sectional view of another alternative embodiment of hydrogen source device;

FIG. 5 is an exploded perspective view of a hydrogen-containing material portion of the device of FIG. 4;

FIG. 6 is a perspective and broken away view of an alternative hydrogen-containing material portion; and

FIG. 7 is a sectional view of the hydrogen-containing material portion of FIG. 6, taken along line VII-VII of FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the FIG. 1, it will be seen that the illustrative hydrogen source device includes a housing 10 with a wall 12 therein, dividing the housing into first and second chambers 14, 16.

The first chamber 14 contains a hydrogen-containing material 18, such as a metal hydride. The metal hydride may be selected from a group of hydrides including lithium hydride, lithium aluminum hydride, calcium hydride, sodium hydride, magnesium hydride, Group IA metal hydrides, and Group IIA metal hydrides. Alternatively, the hydrogen containing material may comprise aluminum foil coated with a polymer bonded hydride composite, or may comprise a polymer-bonded ~~light~~ metal hydride and aluminum in powder form. The first chamber 14 is provided with a discharge conduit 20 extending from the first chamber for release of hydrogen gas from the first chamber. The conduit 20 may extend to a hydrogen consuming device (not shown), such as a fuel cell.

The second chamber 16 houses a reactant 22 adapted to react with the hydrogen-containing material 18 to cause release of hydrogen. The reactant 22 ~~may be selected from a group of~~ preferably is ~~reactants including~~ water, ~~sodium borohydride in solution with sodium hydroxide, and a slurry or light metal hydroxide in oil, or in a caustic solution or suspension~~.

~~In a further alternative arrangement, the~~ The hydrogen containing material may comprise ~~hydrogel and the reactant~~ a lithium hydride

slurry. ~~In still another alternative arrangement, the hydrogen containing material may comprise a polymeric hydrogel and the reactant a lithium hydride slurry in oil~~.

In ~~a still further~~ an alternative embodiment, illustrated in FIG. 2, the hydrogen containing material 18 may comprise a selected one of the aforementioned metal hydrides 18a disposed in a wound ribbon 18b of glass cloth, "jelly roll" fashion. The glass cloth 18b serves as a wicking material which transports the reactant 22 to the interior of the mass of metal hydride 18a.

A bladder 24 is disposed in the second chamber 16 and the reactant 22 is disposed in the bladder. A transfer conduit 26 interconnects the first and second chambers 14, 16 and, more specifically, extends from the bladder 24, through wall 12, and into the first chamber 14 for flowing the reactant 22 from the bladder 24 to the first chamber 14. A check valve 28 is disposed in the transfer conduit 26. The check valve 28 is adapted to open upon decrease in pressure in the first chamber 14 from a selected pressure, and is adapted to close upon the pressure in the first chamber rising to the selected pressure.

A pressurizer 30, which may be a coil spring, is mounted in the second chamber 16 and is adapted to apply pressure to the bladder 24, and thereby the reactant 22, to maintain the reactant at a selected pressure.

In operation, when the hydrogen consuming device requires additional hydrogen, a valve 32 in the conduit 20 opens,

permitting hydrogen to flow from the first chamber 14, through the conduit 20, to the hydrogen consuming device. The flow of hydrogen from the first chamber 14 reduces the pressure in the first chamber to a level below a selected pressure, typically about 50 p.s.i., causing the check valve 28 to open.

The reactant 22 in the bladder 24 is maintained at 50 p.s.i., or other selected pressure, by the spring 30. Thus, opening of the valve 28 causes reactant 22 to flow through the transfer conduit 26 to the first chamber 14, where the reactant 22 reacts with the hydrogen-containing material 18, to effect release of hydrogen in the first chamber 14 and flow of hydrogen therefrom through the discharge conduit 20.

When the hydrogen consuming device has received sufficient hydrogen, flow stops in the discharge conduit 20 and the pressure in the first chamber 14 quickly attains 50 p.s.i., causing the check valve 28 to close, immediately stopping admittance of reactant 22 to the first chamber 14. The spring 30 acts to maintain the 50 p.s.i. selected pressure on the bladder 24 and on the check valve 28. As soon as pressure in the first chamber 14 drops below 50 p.s.i., the check valve opens and another cycle of hydrogen generation commences. The cycles are repeated until the bladder 24 is exhausted of reactant material. At that point, the housing 10 may be disconnected from communication with the hydrogen-consuming device and discarded and replaced with a similar hydrogen source device.

In FIG. 3, there is shown diagrammatically an alternative embodiment in which the second chamber 16 retains the reactant 22 without a bladder, and the pressurizer 30 comprises gas 30a under pressure, rather than a spring.

The operation of the device shown diagrammatically in FIG. 3 is essentially the same as operation of the device shown in FIG. 1. The reactant 22 is maintained at 50 p.s.i., or other selected pressure, by the gas 30a. Opening of the check valve 28, triggered by a pressure drop in the chamber 14, causes reactant to flow through the transfer conduit 26 to the first chamber 14, where the reactant 22 reacts with the hydrogen-containing material 18, to effect release of hydrogen in the first chamber 14.

When hydrogen is no longer required by the hydrogen-consuming device, pressure in the first chamber 14 returns to 50 p.s.i., causing the check valve 28 to close. The gas 30a in the chamber 16 maintains the 50 p.s.i. pressure on the check valve 28. As soon as pressure in the first chamber 14 drops below 50 p.s.i., the check valve opens and another cycle of hydrogen generation begins.

It will be apparent that the device illustrated diagrammatically in FIG. 3 can be configured similarly to the device shown in FIG. 1, that is, with both chambers 14, 16 disposed in a single housing 10 and separated by a wall 12.

In FIGS. 4 and 5, there is shown another alternative embodiment in which the hydrogen-containing material 18 comprises

a selected number of round flat discs 36 of hydride material. Each disc 36 is provided with rigid outer separator coverings 34, on the flat surfaces of the disc, which coverings preferably are of steel or Teflon, and a central orifice 38 extending therethrough. Embedded in each disc 36 and in communication with the orifice 38 is a spirally-wound sparging tube 40 having therein a series of holes 42. The discs 36 are stacked, one on another, in the first chamber 14 on a substantially rigid transfer conduit 44 in communication with the valve 28.

In the embodiment shown in FIG. 4, the second chamber 16 is provided with the gas pressurizer 30a, described hereinabove, and a gas charging valve 46. At the discharge conduit 20, the first chamber 14 is provided with a filter 48, such as a charcoal filter, to remove traces of hydrocarbons.

Referring to FIG. 4, it will be seen that the housing 10 is in two parts, a first part 10a for retaining the hydrogen-containing material 18, and a second part 10b for retaining the reactant 22, such as water. Similarly, the aforementioned wall 12 comprises a first wall 12a constituting an end wall of the housing first part 10a, and a second wall 12b constituting an end wall of the housing second part 10b.

Still referring to FIG. 4, it will be seen that the device includes a hub portion 50 in which is mounted the check valve 28. The hub portion 50 includes a first internally threaded projection 52 and a second internally threaded projection 54. The housing

first part 10a is provided with a first externally threaded projection 56 adjacent the wall 12a and adapted to threadedly engage the hub first projection 52. Similarly, the housing second part 10b is provided with a second externally threaded projection 58 adjacent the wall 12b and adapted to threadedly engage the hub second projection 54. Thus, the housing first and second parts 10a, 10b are readily disengageable from one another, such that, for example, the housing first part 10a may be removed and replaced repeatedly. The housing second part 10b can be re-charged through the charging valve 46. However, if recharging is not in the offing, the second housing 10b may also be easily replaced. To facilitate such interchange of housing components of the device, the hub portion 50 is provided with an on/off actuator 60 for positively closing off the valve 28 during such interchanging operations.

The operation of the device of FIG. 4 is very similar to that of the previously described devices. Opening of the check valve 28, initiated by a pressure drop in the first chamber 14, causes reactant 22 to flow through the valve 28 and transfer conduit 44 to the first chamber, where the reactant flows through the transfer conduit and into the sparging tubes 40 and, thence, into the hydrogen-containing material of each of the discs 36. The reactant 22 reacts with the hydrogen-containing material 18 to effect release of hydrogen in the first chamber 14. The released hydrogen flows between the disc perimeters 62 and the housing side

walls 64, through the filter 48, and exits through the discharge conduit 20 and the valve 32.

In FIGS. 6 and 7 there is shown an alternative disc 70 in which there is substituted for the sparging tube 40, a sparging diskette 72 comprising two wafers 74, of steel or the like, slightly spaced apart and welded together at their peripheries. The wafers 74 are each provided with holes 76 for passage of water from the diskette 72 into the disc 70 of hydrogen-containing material 18.

In the FIG. 4 embodiment, using the discs 36, 70 of either FIG. 4 or FIG. 6, the reactant 22 is substantially evenly distributed through the hydrogen-containing material 18.

There are thus provided hydrogen generating devices of simple configuration and exhibiting finely tuned responses to demands of a hydrogen consuming device.

It is to be understood that the present invention is by no means limited to the particular construction herein disclosed and/or shown in the drawing, but also comprises any modification or equivalent within the scope of the claims.